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Effect of different cultivation methods on strawberry's antioxidant value

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Summary: The small fruit and strawberry production is economically important in Serbian agriculture. The fresh fruit is sold in domestic markets, but the frozen and processed is mainly sold in foreign markets. The growers find themselves in an ever-expanding selection of the varieties, but besides the nursery and breeder's descriptions of new cultivars, there are only few exact results for the biological and economical ability of the varieties, which makes easier to choose the proper cultivar. The performance of the varieties in modern strawberry production is worth to investigate by adaptive cultivation methods and production technique. In the case of new strawberry varieties we know neither their needs in production nor their real capability, so they have to be compared with an older, standard control variety ('Clery'). The breeder's manuals give only references for the needs of the production technique, of the variety, so it is necessary to have facts, which are based on objective testing results. In this work, a new variety ('Joly') is being compared with the control variety. Comparative study of individual varieties are required covering the antioxidant content of the fruits (FRAP) and variability of these amounts in different years of breeding as well as the production techniques under similar circumstances.

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Key words: strawberry, cultivation method, FRAP, Serbia

Introduction

Strawberries are very likely one of the first fruits, which were cultivated by humans Before Christ. Authors from classic era, e.g. Theophrastos from Ancient Greece, Ovid, Pliny, Virgil, from the ancient Rome has been mentioned this fruit as a wild plant and herb.

In the development of today's strawberry (*Fragaria ananassa* Duch. F = Grandiflora Ehrh., 2n = 8x = 56) the most important moment was the Virginian strawberry (*F. virginiana* Duch. F) and the Chilean strawberry (*F. chiloensis* Duch. F) spontaneous hybridization in the XVIII. century, in Brest (France). The new strawberry cultivar inherited its red fruit colour from the Virginian strawberry, fruit size and the excellent flavour from Chilean strawberry (Milivojević, 2010).

The strawberry growing becomes more and more important in worldwide relation for population supplying with food, besides the large amounts of carbohydrates and organic materials, contains a significant amount of antioxidants (anthocyanins, phenolic acid, flavones and flavonoids) and A, E, C vitamins. Both of these substances help to preserve the human health, circulatory disorders and reduce the formation of cancerous lesions chance (Nikolić, 2010).

The World produced 554 million tons of fruit quantity in 2007. Of this amount, the share of strawberries is 1.05% or 5.781.678 tons (FAO Production Yearbook, 2014; Turhan & Paydas-Kargi, 2007).

The strawberry growing covers about 5085 ha in Serbia. The strawberry growing area covers 498 ha in Vojvodina province sharing in 10 % from the total berry area. The average yield in national relation reaches 5 t/ha (Serbian Statistical Yearbook, 2014).

Sturm (2003) has already discovered that consumer satisfaction studies for favourable flavour determined not only by the total sugar content, but also the structure of each sugar, and the ratio is also an important factor. The glucose and fructose predominates to sucrose, the sugar content is increasing parallel from the technological maturity to full maturity direction.

Due to the high content of polyphenols in fruits, they have very good antioxidant effect. In strawberry fruits more anthocyanins, phenolic acid and flavonoids were also detected (Deighton et al., 2002; Scalzo et al., 2005).

Strawberries include a major source of ascorbic acid that being a natural antioxidant which prevents the natural darkening of the fruit skin, and increases shelf life (Lee & Kader, 2000).

The laboratory tests for the fruit are important, especially the traditional and instrumental analytical tests (titratable acidity, Brix%, qualitative analysis of sugars and acids, water-soluble antioxidant content - FRAP) (Tulipani et al., 2008).

Geneticists delight annually both growers and consumers with new varieties more and more satisfying, more beautiful

than ever, more productive and facing many dangerous organism. As a result, the fruit of the strawberry has the fastest type of change among fruits. The novelty value of one new strawberry variety is now estimated just one decade of time (Dénes, 2014).

Materials and methods

Experimental material

The applied varieties were 'Clery' and 'Joly'. The first cultivar is treated as control variety and can be compared to the new perspective variety, 'Joly'.

'Clery'. Breed in Italy. It is a patented variety, property of Mazzoni Group, the distributor in Serbia is Agro-Ferticrop Subotica. Parent partners are (El Santa x FBGL 3) x Sweet Charlie. Medium growth, medium-density bush variety, tolerant to foliar and root diseases. Flowers are plenty of pollen producers, frost resistance is good. Its fruits are uniformly large, conical, bright red, very firm, sweet with good taste. It has very early ripening time, depending on the used cultivation system, one or two weeks before the El Santa. Its yield potential is heavily dependent on the type of plants used, over medium-high in case of Frigo seedlings, very high yield strength when planting from seedling trays. 'Clery' is sensitive to the high lime content of the soil according to Hungarian experience (Dénes, 2014). In our experiment it was the control breed.

'Joly'. It is from the breeding program of variety C.I.V. (Italy), from 2009. It is a protected variety, the distributor in Serbia is Agro-Ferticrop Subotica. Ripening time is 3 days after 'Clery'-s; mid-early, long-maturing, high-yielding variety. Blunt cone-shaped, and the size and consistency of the fruit preserves till the end of the ripening. The plant has big, spectacular, reflected bracts. Its fruit is dark red, very flashy and smooth. The meat is red and the skin is equally hard, it can tolerate the hand-picking. It has an excellent flavour and high sugar content and it is also very fragrant. For 'Joly' is especially important the early planting, otherwise the flowers would be too little: plant them into the ground before July 10. Only first-class flowers are formed on it, so- it has uniformed crop quality. This variety is not sensitive to soil quality, and can widely be cultivated. Requires little nitrogen (in case of surpluses leaves turns white and distorted). This variety is cooled, stored excellent. The flowers are large, well-fertilized. The bush is medium strong growth, tolerant to all soil types. The root system is strong, resistant to root diseases. It has resistance to fungal diseases (slightly more sensitive than 'Clery' to the powdery mildew) (Mišić, 2002; Hotváth, 2013). The capacity of the cultivars at modern strawberry production can be investigated in relation of the production techniques. In our experiment it was the experimental breed.

For the tests A and A- frigo strawberry plants were used taken from Vivai Mazzoni (Italy) company directly through their official distributor in Serbia (Agro-Ferticrop Subotica).

Soil and climate conditions

The soil parameters of the test strawberry orchard in 2015 are shown in *Table 1*. The soil analyse was made in the Soil and Agroecology Laboratory of Novi Sad. Laboratory is accredited by ATS (Serbian Accreditation Body) according to the standard SRPS ISO/IEC 17025:2006, certificate number 01-003.

Table 1. The soil parameters of the test strawberry orchard in 2015.

Cultivation method	pH		$CaCO_3$ %	Org. leaf %	Total N %	AL-P_2O_5 mg/100g	AL-K_2O mg/100g
	KCl	H_2O					
1	7.6	8.59	19.02	3.23	0.221	40.6	24.2
	Alkaline		Well carbonated	Middle	High	High	Optimal
2	7.35	8.24	3.21	2.96	0.195	32.2	28.9
	Alkaline		Lightly carbonated	Middle	Medium	High	High
3	TS 3 AQUASAVE (Klasmann) – for production of vegetable seedlings. Mixture of white sphagnum peat (80%) and frozen through black peat (20%) with addition of nutrients 1.5 g/l and wetting agent. Very fine structure 0–5mm. NPK – 14:14:18, pH-6						

Cultivation methods

Three different cultivation methods are mostly applied spread in Vojvodina (Serbia). These are as follows:

1. Open field as single and double-row cropping system.
2. Plastic greenhouse without heating as single and double-row cropping system.
3. Plastic greenhouse without heating in vertical growing equipment filled with peat as the culture medium.

The three cultivation methods that listed above were examined in this study and the outcomes of cultivation methods at two varieties ('Clery', 'Joly').

Investigations were performed in the spring (May) of 2016 and 2017 around town Senta (Vojvodina) in three location simultaneously, depending on the different production technologies.

The plants were planted in 25.07.2015. Drip irrigation was used (drip tape) to water the strawberry plants, also to dispatch the fertilizer correctly. The threats are shown in *Table 2*. Carried out plant protection works were as follows in *Table 3*.

Table 2. Fertilization plan.

Date	Treatment
15.03	Yara Starter 15-30-15
22.03	YaraLiva™ Calcium
29.03	Ferticare™ 14-11-25
05.04	YaraVita™ Rexolin (Fe)
12.04	Ferticare™ 14-11-25
19.04	YaraKrista MAG (Mg)
26.04	Ferticare™ 14-11-25
02.05	YaraLiva™ Calcium
09.05	Ferticare™ 14-11-25
16.05	Krista K+
23.05	Krista K+
30.05	Krista SOP

Table 3. Plant protection plan.

Date	Active ingredient (trade name)	Pest definition
02.10	iprodione (Rovral)	*Mycospherella fragariae*
20.03	thiofanat-methyl (Funomil)	*Rhizoctonia fragariae*
10.04	copper oxychloride	*common leaf spot*
15.04	boscalid+pyraclostrobin (Signum)	*Botrytis cinerea*
20.04	methomyl (Lannate)	*Tropinota hirta*
30.04	procymidone (Sumilex)	*Botrytis cinerea*
04.05	chlorpyrifos+cipermethrin (Konzul)	*Frankliniella occidentalis*
15.05	deltamethrin (Decis)	*Aphis forbesi*
20.05	fenhexamid (Teldor)	*Botrytis cinerea*
30.05	cyprodinil+fludioxonil (Switch)	*Botrytis cinerea*
10.06	abamectin (Abastate)	*Frankliniella occidentalis*

Sample preparation

The fruit was picked once at the ripening stage of 90%. In case of the three cultivation method the selected sample consisted of 10 plants per field. The tests were repeated in 2016 and in 2017.

The samples (2 kg/cultivars) were homogenized after picking in a blender and stored in the freezer at -28 °C until analysis. After defrosting and centrifugation; samples were taken from the supernatant refraction. We examined the physicochemical parameters and water soluble antioxidant capacity (FRAP) in 3 replicates.

The ferric reducing/antioxidant power (FRAP) assay

The ferric reducing/antioxidant power (FRAP) assay was carried out according to Benzie and Strain (1996). The FRAP assay is based on the reduction of the Fe^{3+}-2,4,6-tripyridyl-S-triazine complex to the ferrous form (Fe^{2+}) and the intensity of the reaction is monitored by measuring the change of absorption at 593 nm.

Statistics

Statistical analyses were performed using SPSS 22.0 statistical software package.

Results and discussion

In 2016 in the case of the control breed 'Clery' the highest antioxidant average value was found applying plastic greenhouse cultivating technology: 24.87mM/l (±0.38). The result in the case of vertical cultivating technology was 23.64mM/l (±0.61). In the case of open field cultivating technology the antioxidant value was significantly lower: 8.70mM/l (±0.37).

In 2016 in the case of the experimental breed 'Joly' the highest antioxidant value was found applying vertical cultivating technology: 25.55mM/l (±0.25). The result in plastic greenhouse cultivating technology was 25.32mM/l (±0.13). In the case of open field cultivating technology the antioxidant value was significantly lower: 10.03mM/l (±0.27).

Comparing the two breeds significant differences were found in the case of all three cultivating technologies (p=0.000). In the case of vertical, plastic greenhouse and open field technology also the breed 'Joly' showed better results (*Figure 1*).

In 2017 in the case of the control breed 'Clery' the highest antioxidant average value was found applying open field cultivating technology: 40.87mM/l (±1.69). The antioxidant average value was a little bit lower in the case of vertical cultivating technology: 25.69mM/l (±0.91). In the case of plastic greenhouse cultivating technology the antioxidant value was significantly lower: 16.97mM/l (±1.51).

In 2017 in the case of the experimental breed 'Joly' the highest antioxidant average value was found applying open field cultivating technology: 43.37mM/l (±0.79). The antioxidant average value was a little bit lower in the case of vertical cultivating technology: 30.11mM/l (±1.85). In the case of plastic greenhouse cultivating technology the antioxidant value was significantly lower: 28.69mM/l (±0.91).

Comparing the two breeds significant differences were found in the case of all three cultivating technologies (p=0.000). In the case of vertical, plastic greenhouse and open field technology also the breed 'Joly' showed better results (*Figure 2*).

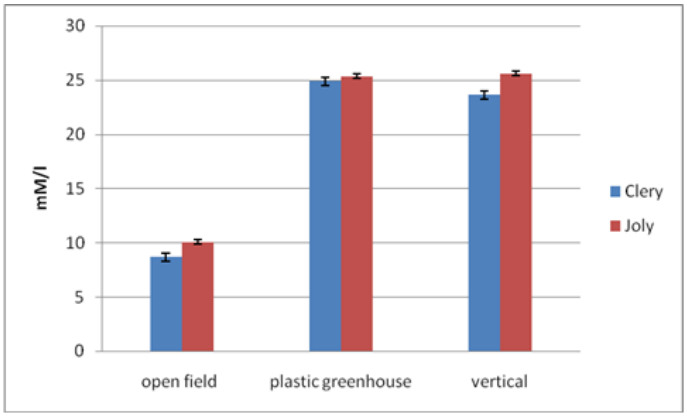

Figure 1. The average antioxidant values in 2016 in the case of the three cultivation technologies.

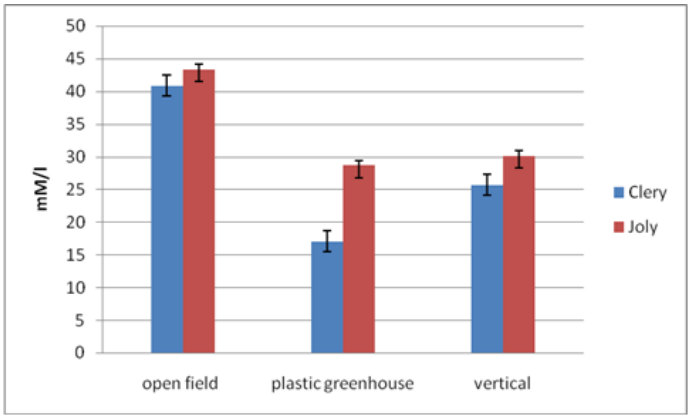

Figure 2. The average antioxidant values in 2017 in the case of the three cultivation technologies.

Comparing the results got in 2016 and 2017 significant differences were found in the case of all three cultivating technologies in the case of two breeds (p=0.000). In the case of vertical, plastic greenhouse and open field technology and in the case of the control breed 'Clery' and the experimental breed 'Joly' the year 2017 showed better results.

Discussion

Both varieties are early ripening, the experimental breed 'Joly' comes a few days later than the control breed 'Clery'. In Serbia the ripening period starts in the first decade of May (in plastic greenhouses around seven-ten days earlier) and it lasts approximately three weeks.

There are a significant difference between antioxidant content of the fruits because the experimental breed 'Joly' significantly outperforms the control variety for all three cultivation methods of breeding for both years of examination.

In 2016 in the case of the experimental breed 'Joly' the highest antioxidant value was found applying vertical cultivating technology: 25.55mM/l (±0.25).

In 2017 in the case of the experimental breed 'Joly' the highest antioxidant average value was found applying open field cultivating technology: 43.37mM/l (±0.79).

Comparing the two age groups (2016 and 2017) the weather conditions were slightly different (rainfall difference is 120 mm plus in the whole vegetation period in 2016, the air temperature, humidity were the same in both years).

Comparing the results got in 2016 and 2017 significant differences were found in the case of all three cultivating technologies in the case of two breeds (p=0.000). In the case of vertical, plastic greenhouse and open field technology and in the case of the control breed 'Clery' and the experimental breed 'Joly' the year 2017 showed better results.

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